SRAM DETECTOR CALIBRATION

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ABSTRACT

Custom proton sensitive SRAM chips are being flown on the BMDO Clementine missions and Space Technology Research Vehicle experiments. 'l'his paper describes the calibration 'procedure for the SRAM proton detectors and their response to the space environment.

SUMMARY

The SRAM detector has an offset voltage that adjusts the cell critical charge to upset, allowing the LET (Linear Energy Transfer) threshold to be set below the value at which its cells will upset.. This threshold can be set below the charge deposited by protons passing through, or stopping in, the charge collection region. The detector was calibrated with protons using the Caltech Tandem Van de Graaff and alpha particles using radioactive sources.

The SRAM design was submitted to the MOS Implementation System (MOSIS) and fabricated at a 1.2-mm n-well. double-metal CMOS/epi foundry. A schematic diagram of the SRAM cell is shown in Figure 1 . This cell differs from that of a standard six-transistor SRAM cell as described in references [1 ,2] . in operation all the memory cells are written into a "sensitive" state where Mn2 is turned OFF and Mp2 is turned ON, connecting V. to the sensitive drain, Dn2. V_{DD} is then lowered to 3 V -and V. is lowered below V_{DD} = 3 V allowing the SRAM to accumulate upsets at a given V_O value. Thereafter V. and V_{DD} are returned to 5 V and the cells read to determine the number of upsets. This cycle is repeated at different values of V. during calibration. If Vo is lowered to the cell. metastable point, the cell will spontaneously flip, as shown in Figure 2. The mean offset voltage, $V_{s\mu}$, at which half of the SRAM cells have spontaneously flipped, defines the zero energy channel of the SRAM spectrometer system. Figure 2 identifies the chip used for proton measurements and the chip used for alpha particle measurements. The mean offset, voltage, $V_{o\mu}$, for charged particle beams, shown in Figure 3, define the gaussian peak at the mean energy deposited by the charged particles [1,2].

The SRAM is calibrated by measuring its upset capacitance and LET threshold. The upset capacitance measurement utilizes particle beams that stop in the charge collection region, below the sensitive drain. For these particle beams all of the charge deposited below the metallization overlayers, or dead layer, is collected by the SRAM cell.. 'The upset capacitance Cu/k(MeV/V), as a function of overlayer thickness, $\partial X3$ (µm), is shown in Figure 4. As the overlayer thickness decreases, more energy, $\partial E4$ (MeV) , is collected by the SRAM cell. The upset capacitance is given by Cu/k(MeV/V) =- $\partial E4/\partial V_{o\mu}$, where $\partial V_{o\mu} \approx (V_{o\mu} - V_{s\mu})$, and $V_{s\mu}$ and $V_{o\mu}$ are shown in Figures 2 and 3. The LET measurement utilizes particles that pass through the charge collection region. All of the energy, $\partial E4$ (MeV), deposited within the effective charge collection depth, $\partial X4$ (µm), is collected by the SRAM cell. The energy deposited by these particles is given by, $\partial E4 \text{ (MeV)} = \partial V o\mu \times Cu/k$, and the effective charge collection depth, $\partial X4$ (µm), is the distance below the overlayer required for a charged particle to deposit $\partial E4$ (MeV) of energy. The LET, in units of keV/µm, shown in Figure 5, is given by $\partial E4/\partial X4$ (keV/µm).

The operation of the SRAM is shown in Figure 6. The energy spectra is produced by 20 MeV proton straggling in 83 mils of Al shielding. A Monte Carlo was used to produce the data points and the curve is a gauss fit, to the data. The above calibration is used to determine that portion of the spectra that will cause upsets in the SRAM with $\partial V o\mu = 0.061$ V. Protons with energy less than E (rein) do not penetrate the overlayer with enough energy to cause an upset, arid protons with energy great, er than F? (max do not have sufficient LET to cause an upset.

ACKNOWLEDGMENTS

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REFERENCES

1. B. R. Blaes, G. A. Soli, and M. G. Buehler, "Bench--Level Characterization of a CMOS Standard--Cell L)- Latch Using Alpha-Particle Sensitive 'l'est. Circuits," IEEE Trans. on Nuclear Science, NS-38, 1486-1492, (December 1991).

2. G. A. Soli, B. R. Blaes, and M. G. Buehler, "Proton-Sensitive Custom SRAM Detector," IEEE Trans. on Nuclear Science, NS--39, 1374--1378, (October 1992).

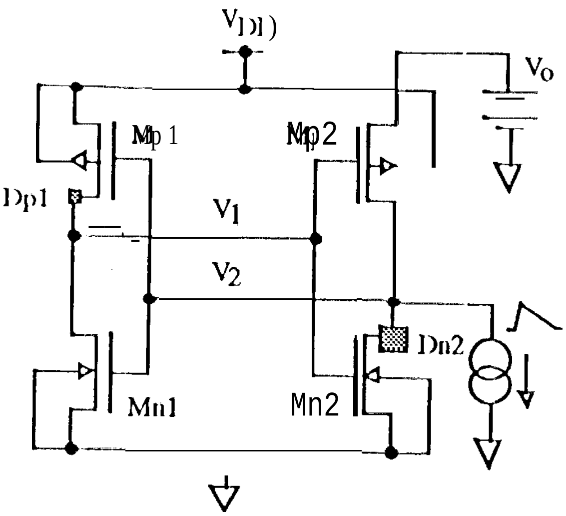

Figure 1. schematic diagram of the SRAM cell showing the placement of V. and the bloated n-drain, Dn2.

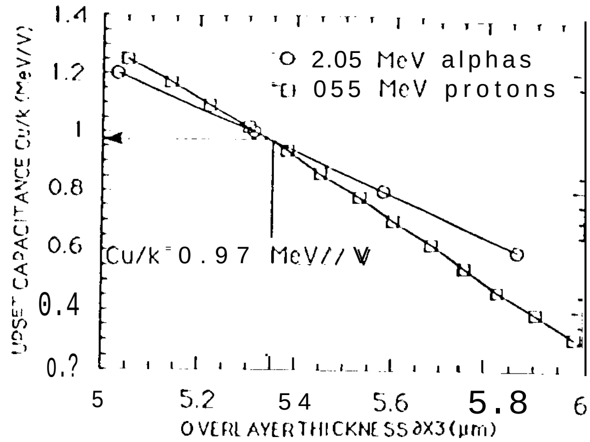

Figure 4. upset capacitance measurement with particles that stop in the charge colliction region.

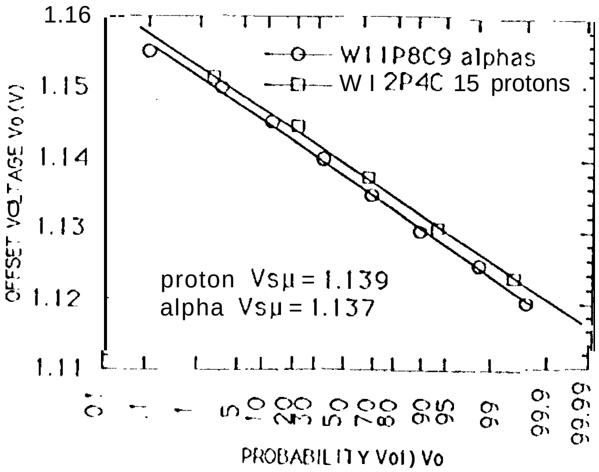

Figure 2. spontaneous flip voltages for the two SRAM detectors used in this experiment.

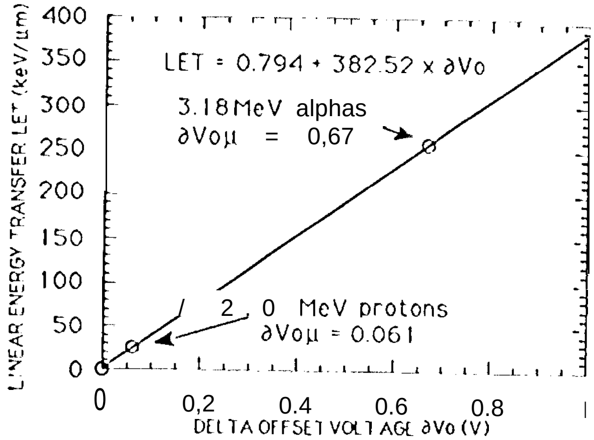

Figure 5. LET threshold measurement with particles that pass through the charge collection region.

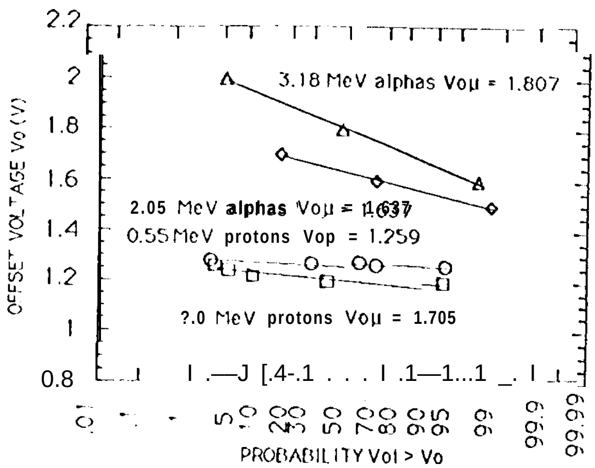

Figure 3. measured mean offset voltages, Voμ.

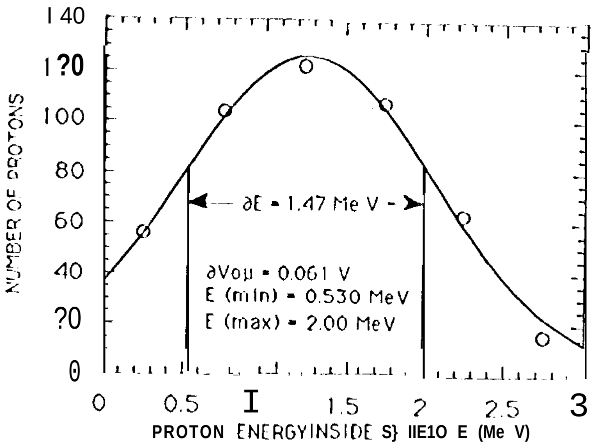

Figure 6. 2(I MeV normal incident proton energy spectra after passing through 83 mils of Al shielding.